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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A61B 5/00

A1

(11) International Publication Number: WO 98/08431

(43) International Publication Date: 5 March 1998 (05.03.98)

(21) International Application Number: PCT/GB97/02307

(22) International Filing Date: 27 August 1997 (27.08.97)

(30) Priority Data:
9617915.5 28 August 1996 (28.08.96) GB

(71)(72) Applicant and Inventor: TESSAL, Stephan [GB/GB]; 5th floor, Dolcis House, 87/89 New Bond Street, London W1Y 9LA (GB).

(74) Agent: BURFORD, Anthony, F.; W.H. Beck, Greener & Co., 7 Stone Buildings, Lincoln's Inn, London WC2A 3SZ (GB).

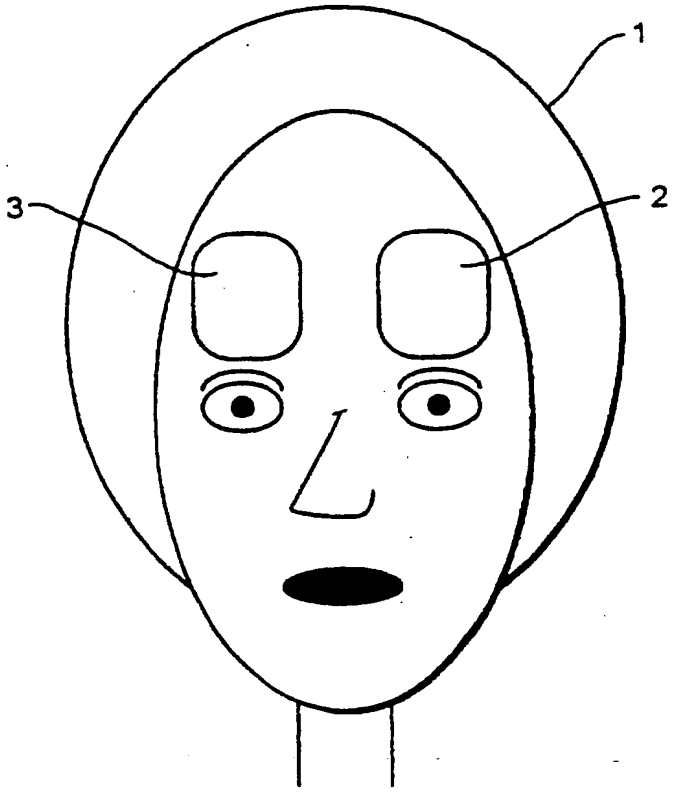
(81) Designated States: AU, CA, IL, JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: METHOD AND APPARATUS FOR DETERMINING STRESS

(57) Abstract

Stress in a subject is indicated by measuring a difference in temperature between symmetrically located left and right skin portions which are subject to asymmetrical temperature changes in response to emotional stimulus of the subject, correlating said difference against a sample data set of mean baseline resting values, and providing a signal if the temperature difference deviates from said data set by at least a predetermined amount or within a predetermined range. The method permits of lie detection and security screening by the non-invasive measurement of the left and right sides of the forehead and determining whether the differential temperature between the two sides is within first or second predetermined temperature ranges depending upon whether the left side is cooler or warmer than the right side.



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METHOD AND APPARATUS FOR DETERMINING STRESS

The present invention relates to a method of and apparatus for determining stress and has particular application to polygraphy or lie detecting.

Various methods of polygraphy are known. Conventional methods have used measurements of the subject's heart rate and perspiration rate, for example, as an indicator of when the subject might be lying or attempting some deceit. Measuring instruments are attached to the subject's body to obtain the desired measurements. Such techniques are not generally of much use when security screening of a high throughput of people is required. Security screening of this kind is often required at airports and ferry ports, for example, and it is desirable not to alert the subjects to the fact that they are being screened.

In airports or ferry ports, much reliance is based on the members of staff who carry out the security screening. Such members of staff, through experience, may be able to identify potential terrorists or smugglers by the activities of such persons. A terrorist or smuggler might look nervous, for example, and may display the well known symptoms of nervousness. However, this method is reliant on the experience and vigilance of the port staff to detect any potential terrorist or smuggler. Furthermore, experienced terrorists or smugglers can disguise any nervousness and appear perfectly normal and therefore not be detected because of any nervous behaviour.

It is also desirable to carry out security screening in a manner which is non-invasive (i.e. does not involve physical contact with the subject) so that innocent persons are not troubled by the screening process.

subject is under stress produced, for example, by lying or seeking to evade detection as a terrorist or smuggler. In particular, it has been found that, for at least a substantial proportion of the population, such stress results in a detectable quantitative deviation from a sample data set of mean baseline resting values, which deviation is dependent upon the identity of the cooler side of the forehead.

According to its broadest method aspect, the present invention provides a method of determining whether a person is under stress, the method comprising measuring a difference in temperature between symmetrically located left and right skin portions which are subject to asymmetrical temperature changes in response to emotional stimulus of the person, correlating (e.g. comparing) said difference against a sample data set of mean baseline resting values, and providing a signal if the temperature difference deviates from said data set by at least a predetermined amount or within a predetermined range.

In the corresponding broadest apparatus aspect, the present invention provides an apparatus for determining whether a person is under stress, the apparatus comprising differential temperature measuring means for measuring a difference in temperature between symmetrically located left and right skin portions which are subject to asymmetrical temperature changes in response to emotional stimulus of the person; correlation means for correlating said difference against a sample data set of mean baseline resting values; and signal output means providing a signal if the temperature difference deviates from said data set by at least a predetermined amount or within a predetermined range.

temperatures of the respective parts are measured with an infra-red camera having its output connected to, for example, a digitiser for digitising the output of the camera.

The temperature difference may be determined and correlated using a neural net.

In most people, it is found that the left side of the forehead is naturally cooler than the right side. In others, the left side of the forehead is warmer than the right side. In either case, if the person is under stress, it is understood that there is an increased right frontal lobe activity. It is believed that this causes the left side of the forehead to become relatively warmer compared to the right side when the person is under stress. This can occur if the person is lying or attempting to smuggle illegal substances for example.

If, as in the case of forehead asymmetrical temperature differences, some people normally have under (non-stressful) resting conditions a left side skin portion cooler than the symmetrical right side skin portion whilst others have the right side skin portion cooler than the left side skin portion, a data set is provided for each type.

The signal can be an audio or visual alarm, the electronic, photographic or other recordal of an image of the person for storage or onward transmission to a location downstream of that at which the temperature measurement is made, or a signal to trigger such recordal. For example, the temperature could be surreptitiously made by non-invasive thermoimaging during departure from an aeroplane, ship or other vehicle or at a passport or other identity checking location and the image transmitted to customs,

(as measured by three-dimensional thermography) may be 0.15°C to 0.17°C. Corresponding ranges apply when measured by less accurate two-dimensional methods such as those of the initial experiments reported below.

The present invention also includes methods of polygraphy and methods of security screening using the methods described above.

The invention further includes polygraphy apparatus and security screening apparatus including the apparatuses described above.

The following is a description by way of example only and with reference to the accompanying drawings of a presently preferred embodiment of the present invention. In the drawings:

Fig. 1 is a schematic view of apparatus according to a presently preferred embodiment of the present invention;

Fig. 2 is a schematic diagram showing a person's face; and,

Fig. 3 is a section of a three-dimensional temperature contour map of a person's forehead.

It has been found that people normally have temperature differences between the left and right sides of the forehead. In a sample experiment, the temperature of the left and right sides of the forehead was measured for two hundred people. The maximum difference between the left and right forehead temperature was recorded for each subject.

The subjects were sat in a darkened room which was maintained at a constant temperature of 22.5°C. EEG electrodes were connected to monitor the subject's heart rate. The subject was interviewed for five minutes on a

It is believed that the right frontal lobe of the brain shows increased activity when a person is lying or otherwise trying to deceive an interviewer. This would explain why the left side of the forehead increases in temperature relative to the right side of the forehead during lying, i.e. when the subject is under stress. This is because the activity of the right frontal lobe is known to excite the heart rate. Possibly blood flow is directed to the right side of the brain so there is a dilation of the blood vessels relative to those in the left hemisphere of the brain. This causes more blood to flow to the right hemisphere than to the left, resulting in the temperature of the left hemisphere increasing.

The apparatus for measuring the forehead temperatures included an infra red camera which was focused on the subject's face. The output of the camera was digitised. Using appropriate software, boxes could be outlined on an image of the subject's forehead in similar manner to that reported in Kagan et al (supra). This is shown in Figure 2. In Figure 2, an image 1 of a subject's face has a box 2 drawn for the left side of the forehead and another box 3 for the right side of the forehead. The use of such boxes 2,3 allows regions outside of the half of the forehead being studied to be included or allows regions from the half of the forehead being studied to be excluded, at will. This allows errors in the obtaining of temperatures on the sides of the forehead to be eliminated or at least reduced to a minimum.

Furthermore, by using a three-dimensional contour map of a thermograph of the subject's face, the edges of the left and right forehead regions could be more clearly identified because they were surrounded by regions of lower temperature. This is shown in Figure 3, which is a section through a portion of the three-dimensional temperature

so that they are not aware of the screening process taking place.

The digitiser 11 converts the output from the camera 10 into digital form for analysis by a computer or other data processor 12 connected to the output of the digitiser 11. The data processor might be an expert system or neural net, for example.

The computer 12 processes the information from the digitiser 11. In particular, under software control, the computer 12 identifies the regions 2,3 of the left and right sides of the forehead of the subject 1 and calculates the temperature difference between the left and right sides. This may be done by averaging ten images taken over a short period for the particular subject 1. The boxes 2,3 can be identified by the computer 12 by analyzing a three-dimensional temperature contour map of the subject's face. The boxes 2,3 can be identified as they are bounded by distinct regions of lower temperature as indicated in Figure 3. For example, the temperature measured over the subject's face can be differentiated over the entire surface and the edges 4 of the hot parts of the subject's forehead corresponding to the boxes 2,3 can be identified by the rapid change in slope as indicated in Figure 3.

The temperature difference between the two sides of the forehead is then calculated. This may be done by subtracting the temperature of the right forehead from that of the left forehead. The average of ten images can then be calculated.

If the value is positive (i.e. the left side is warmer than the right side) and in the range of 0.15°C to 0.17°C, then an alarm can be signalled on a screen of a visual display unit 13 to which the computer 12 is connected.

CLAIMS:

1. A method of determining whether a person is under stress, the method comprising measuring a difference in temperature between symmetrically located left and right skin portions which are subject to asymmetrical temperature changes in response to emotional stimulus of the person, correlating said difference against a sample data set of mean baseline resting values, and providing a signal if the temperature difference deviates from said data set by at least a predetermined amount or within a predetermined range.

2. A method as claimed in Claim 1, wherein said method comprises the steps of:

measuring a difference in temperature between symmetrically located left and right skin portions which are subject to asymmetrical temperature changes in response to emotional stimulus of the person;

correlating said difference against a predetermined temperature range; and

providing a signal indicative of a temperature difference within said temperature range.

3. A method as claimed in Claim 1 or Claim 2, wherein, under resting conditions, said left side skin portion or said right side skin portion can be cooler than the other side portion, depending upon the subject, and a said data set is provided for each type.

4. A method as claimed in Claim 3, wherein said skin portions are at left and right sides of the forehead.

5. A method as claimed in Claim 4, wherein said method comprises the steps of:

12. An apparatus for determining by a method as claimed in Claim 1 whether a person is under stress, the apparatus comprising differential temperature measuring means for measuring a difference in temperature between symmetrically located left and right skin portions which are subject to asymmetrical temperature changes in response to emotional stimulus of the person; correlation means for correlating said difference against a sample data set of mean baseline resting values; and signal output means providing a signal if the temperature difference deviates from said data set by at least a predetermined amount or within a predetermined range.

13. An apparatus for determining by a method as claimed in Claim 2 whether a person is under stress, the apparatus comprising:

differential temperature measuring means for measuring a difference in temperature between symmetrically located left and right skin portions which are subject to asymmetrical temperature changes in response to emotional stimulus of the person;

correlation means for correlating said difference against a predetermined temperature range; and

signal output means providing a signal indicative of a temperature difference within said temperature range.

14. An apparatus for determining by a method as claimed in Claim 4 whether a person is under stress, the apparatus comprising:

differential temperature measuring means for measuring a difference in temperature between the left and right sides of the person's forehead;

correlation means for correlating said difference against a first predetermined temperature range when the left side is cooler than the right side, and for correlating said difference against a second predetermined

FIG. 1

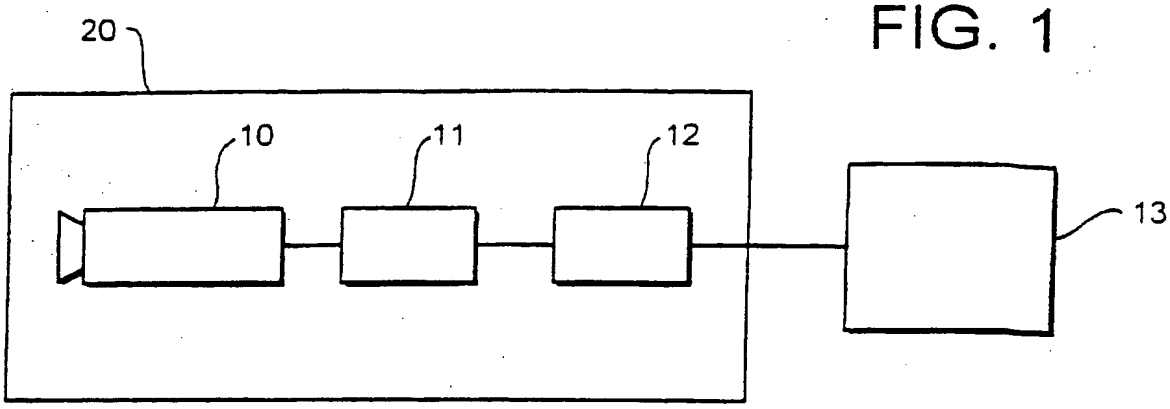
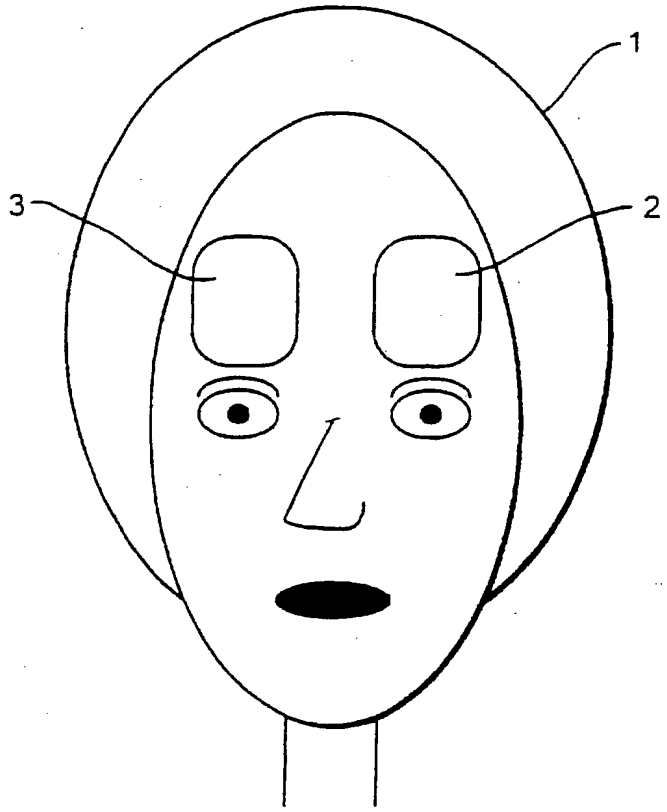


FIG. 2



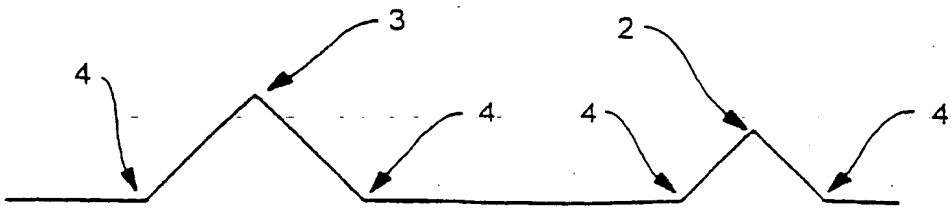


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/02307

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	J. KAGAN ET AL.: "Asymmetry of Forehead Temperature and Cardiac Activity" NEUROPSYCHOLOGY, vol. 9, no. 1, 1995, pages 47-51, XP002050262 cited in the application see page 48 - page 49; figure 1	1-5,7-9, 12-17
A	WO 94 05206 A (J. BOCZAN) 17 March 1994	1-3
A	see page 3, line 1 - line 27 see page 4, line 3 - line 19 see page 5, line 23 - line 34 see page 7, line 9 - line 37	12,13

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